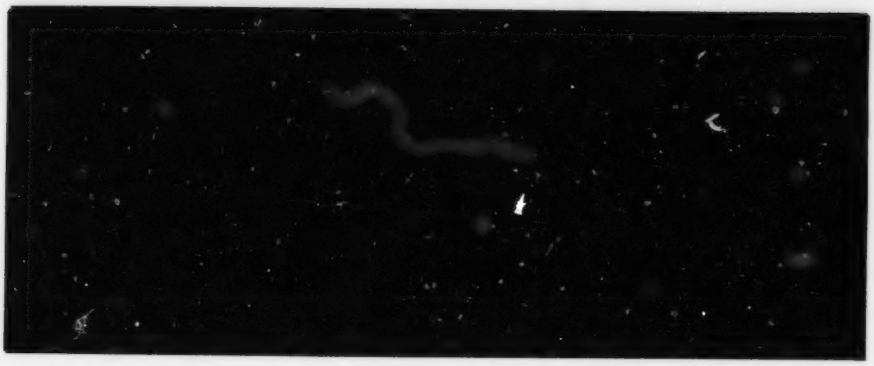
ADF

Saskatchewan
Agriculture
Development Fund

Keeping the agriculture and food industries competitive through Research, Development and Demonstration.



91-02568/

Final Report

2.1-16

Improvement of Reproductive Efficiency in the Gilt

Conducted by Dr. N. C. Rawlings
Western College of Veterinary Medicine

Funded by the Agriculture Development Fund

2.1-16

Canada/Saskatchewan ERDA Agreement
Project No. 2.1-16 (1988)

Improvement of Reproductive Efficiency in the Gilt

Principal Investigator: Dr. N.C. Rawlings, W.C.V.M.

Final Report
30/4/90

Executive Summary

Abstract

Our objective was to improve the efficiency of reproduction in the gilt, specifically by developing more consistent methods of inducing first estrus in gilts and by developing methods to predict the early onset of estrus and fertility in young developing gilts. Gilts which exhibit first estrus within 60 days after boar exposure had higher basal pituitary hormone concentrations than gilts which failed to show estrus. Gilts which will exhibit first estrus before 200 days of age can be identified by their blood luteinizing hormone concentration at 80 days of age. These results suggest that pituitary maturation early in the gilt's life is crucial for expedient sexual development.

Summary

While gilts will reach market weight by 150 days, few of them will show estrus by this time, even with such methods of stimulation as boar introduction. Not all gilts eventually bred will farrow and of those farrowing a large proportion will produce small litters. To guarantee sufficient gilts that will cycle, breed, become pregnant and farrow producing an acceptable litter size, the producer is required to retain, beyond market weight, a much larger group of gilts than he needs as replacements. With a high rate of sow replacement and the unpredictability described above, reproductive management of the developing gilt is critical for efficient production. It would be beneficial to be able to advance reproductive maturation and first estrus so that only cycling gilts are retained past market weight. Additionally, it would be of great value to be able to predict which gilts will cycle early and be of good fertility.

To these ends we have characterized the hormone profiles of gilts exposed to mature boars and we have developed a simple blood test to identify gilts which will exhibit estrus cycles before 200 days of age. The cut-off age of 200 days for first estrus used in this study allows for two to three 21 day estrous cycles before breeding, subsequent farrowing of a first litter before the gilt is one year old; thus maximizing economic return from the replacement gilt.

Boar introduction will induce first estrus in most, but not all, gilts. The hormone profile of responding gilts differs from the non-responding animals in that the basal levels of luteinizing hormone (LH), a pituitary reproductive hormone, are higher in the

responders following boar exposure. These levels remain high up to 20 days post-exposure. This suggests that pituitary hormone release in responding gilts may be influenced by the visual, olfactory and auditory cues provided by the boars. Non-responding gilts may be physically immature and unable to alter pituitary hormonal output. The possibility exists, then, that elevation of LH levels through hormone therapy may increase the number of gilts which will respond to boar stimulation with first estrus before 200 days of age. This would enable a producer to make use of a greater percentage of the available replacement animals and thus the total number of gilts on hand could be decreased. This would lead to savings on housing, feed and labour.

An alternative approach to improving gilt management centres on the prediction of which gilts will exhibit regular estrous cycles before 200 days of age. Hormone patterns were assessed in 43 gilts until they reached market age, approximately 150 days. Gilts were grouped by age at first estrus and the concentrations of various hormones compared between groups. At 80 days of age, gilts which eventually exhibited estrus before 200 days of age had much higher LH levels than did gilts which failed to exhibit estrus within the time course of the experiment. Concentrations of other reproductive hormones were of no predictive value.

The significance of this data is two-fold. First, from a practical stand-point, a simple blood test, performed on all replacement gilts at 80 days of age, could identify gilts with the greatest potential for efficient reproduction long before market age. At market weight, the remainder of the gilts could be sold. This would lead to a decrease in the number of gilts in the replacement herd, more efficient use of capital resources and a substantial reduction on overweight penalties at the stockyard. Secondly, from a scientific point of view, the increase in hormone concentrations at this young age in normally developing gilts indicates that a turning point in sexual maturation is occurring. Further research focused at this age may yield additional information regarding the mechanism of mammalian puberty.

Technical Report

Abstract

While gilts will reach market weight by 150 days, few of them will show estrus by this time, even with such methods as boar introduction. Additionally, not all gilts will cycle sufficiently early to produce a first litter by one year of age. This necessitates the maintenance of a much larger group of gilts than the producer requires as replacements. The capital investment in the replacement herd is substantial. To improve the reproductive efficiency of the gilt we have investigated the mechanism of boar stimulation of first estrus and we have developed a blood test to identify gilts which will cycle by 200 days of age. Boar introduction causes an increase in basal LH concentrations in gilts which eventually exhibit their first estrus before 200 days of age. This suggests that boar exposure can be an integral part of management to stimulate sexual maturation in the gilt. At 80 days of age, gilts which eventually exhibit their first estrus before 200 days of age have elevated LH values compared to gilts which fail to cycle. This result has the potential of development into a simple commercial test to identify gilts with the most promising reproductive future.

Background and Objectives

The pattern of development of the reproductive system has been studied in gilts (1), as have the patterns of hormones thought to be important to reproduction (2). Sexual development appears to consist of two 10 week periods followed by a resting phase prior to first estrus (1,2). Because blood hormone levels vary in a subtle minute to minute pattern, to understand hormone changes and how they control reproduction, we need to use very intensive blood sampling regimes, such as are employed in this study (5). We do not understand how the pattern or rate of development is controlled, or how boar and stress induction of first estrus in the young gilt is effective (1,2,3). Boar introduction will induce first estrus in a few, but not all, gilts (4). By studying hormone patterns in responding and non-responding gilts we hope to be able to develop better methods of estrus induction. In other farm species attempts have been made to predict fertility based on hormone levels in young animals; the time of onset of estrus in the gilt may be closely correlated to hormone changes during sexual maturation, allowing us to develop a blood test to predict the timing of a gilt's first estrous cycles (6).

Selected References

(1) Dyck, G.W. and Swiestra, E.E. 1983. Can. J. Anim. Sci. **63**: 81-87.
(2) Camous, S., Prussier, A. and Pelletier, J. 1985. J. Anim. Sci. **60**: 1308-1317.
(3) Christensen, R.K. 1986. J. Anim. Sci. **63**: 1280-1287.
(4) Dyck, G.W. 1987. Can. J. Anim. Sci. In press.
(5) Rawlings, N.C., Jeffcoate, I.A. and Rieger, D.L. 1984. Theriogenology **22**: 473-488.
(6) Binden, B.M. and Turner, H.W. 1974. J. Reprod. Fertil. **39**: 85-88.

Experimental Methods

(1) Induction of first estrus in the gilt

Mature intact boars have been introduced to a total of 24 135 day old gilts. Intensive blood samplings of gilts immediately before and after boar introduction, as well as 10 and 20 days following initial exposure, have been obtained in 19 gilts to see the effect of the boar introduction on patterns of blood hormones important in reproduction.

Intensive blood sampling was conducted 24 hours after gilts were anaesthetized and catheters introduced into a blood vessel in the neck. Some technical problems were initially encountered and subsequently overcome. Only data from animals which remained healthy throughout the experiment was used in the analysis.

Blood samples from the intensive bleeds were analyzed by radioimmunoassay for the concentration of luteinizing hormone (LH) and follicle stimulating hormone (FSH), pituitary gland products important in reproduction, as well as cortisol, a hormone that is classically thought to be indicative of stress levels.

(2) The prediction of the timing of first estrus in the gilt

(a) Blood samples were collected every 3 weeks from 43 gilts beginning at 61 days of age and finishing at 144 days of age. Serum samples were analyzed for LH, FSH and estradiol (E_2) by radioimmunoassay.

Gilts were continuously exposed to a mature boar starting at 135 days of age and checked daily to 200 days of age for external signs of estrus including a red swollen vulva. Those achieving estrus between days 140-160 were designated the early group, between days 160-180 the middle group, between days 180-200 the late group and those which did not exhibit estrus by 200 days of age were placed in the non-cycling group.

Hormone concentrations were compared between the four groups as well as between all gilts which exhibited first estrus before 200 days of age and gilts in the non-cycling group.

Statistical analysis of the mean values of LH, FSH and estradiol between each group within each sampling time was done using a two-way analysis of variance (ANOVA). Group means were compared using orthogonal contrasts analyzed with Scheff's S test ($P < 0.05$).

(b) Eighteen gilts were treated as above except that at 60, 80 and 100 days of age intensive blood sampling was conducted to further characterize the increase in LH seen at 80 days in part a of this experiment. As LH is released in a pulsatile fashion, pulse amplitude and frequency as well as mean and basal concentrations of the hormone can be determined from frequent samples. Gilts were again divided into groups based on age at first estrus and the hormone concentrations compared between groups.

Results and Discussion

(1) Induction of first estrus in gilts

Blood samples were analyzed for LH, FSH, and E_2. We have shown, for the first time, a clear stimulation of basal LH secretion, by boar introduction, in gilts which exhibit

first estrus before 200 days of age. This increase persists up to 20 days post-exposure. This is exciting as it gives a link between boar introduction and stimulation of the onset of reproductive cyclicity in the gilt. Hormone therapy to boost the basal levels of LH in gilts may be sufficient to mimic the boar effect or else may be effective at increasing the number of gilts which respond to the presence of mature boars.

There were no differences in LH pulse amplitude, frequency or mean LH concentrations between responding and non-responding gilts. Likewise, neither FSH nor cortisol values were different between responding and non-responding gilts following boar exposure.

(2) The prediction of the timing of first estrus in the gilt

(a) Table 1 shows that, at 81 days of age, gilts which first achieve estrus early have significantly higher LH concentrations than do those gilts which achieve estrus later on, or not at all. Those gilts which never showed external signs of estrus had significantly lower LH values than the gilts which did cycle.

Table 2 shows that gilts which never exhibited a first estrus have significantly lower FSH concentrations, until 123 days of age, compared with those gilts which cycled early or late.

There were no significant differences in estradiol concentrations between groups before 144 days of age.

These results are very exciting and of great potential. This transient elevation of LH may reflect an important step in hormonal maturation and as such presents the possibility of manipulation to increase the number of gilts which achieve estrus early.

(b) The parameters of pulsatile LH release increase significantly between 80 and 100 days of age. The actual pattern of LH secretion also varied between early and late cycling gilts. This suggests that not only is LH secretion at 80 days a predictor of the time of onset estrus cycles, but this indeed may be a critical stage of development. Studying this period further may allow us to understand the control and timing of the process of development and hormonal manipulation at this time could allow us to manipulate the time of first estrus and perhaps improve and synchronize ovulation rate and fertility.

Conclusions and Impact

This study has been very productive in that both the scientific and commercial objectives have been met. We have shown that boar stimulation results in an increase in basal LH concentrations and that LH levels are elevated at 80 days of age in gilts which eventually exhibit their first estrus before 200 days of age. This latter result has the potential of being developed into a simple commercial test to identify gilts with the most productive reproductive future. Hormone therapy to boost LH concentrations around the time of boar introduction may also prove beneficial by increasing the number of responding gilts. Unsuitable animals, once identified as such, can be sold at market weight thus leading to savings on overweight gilts at the stockyards. The overall result is the more efficient and economical management of the replacement gilt herd.

Publications and Presentations

1) D.L. Kingsbury and N.C. Rawlings (1989). Prediction of first estrus in the gilt. Prairie Swine Centre Annual Report p. 35-37.

2) D.L. Kingsbury and N.C. Rawlings (1990). Prediction of first estrus in the gilt. Presented at the Canada West Society for Reproductive Biologists Annual Winter Meeting, Vancouver, B.C.

3) D.L. Kingsbury and N.C. Rawlings (1990). Prediction of first estrus in the gilt. To be presented as a poster at the American Society for Animal Science Meeting, Ames, Iowa July 31-August 3, 1990.

4) D.L. Kingsbury and N.C. Rawlings (in preparation). Luteinizing hormone can be used to predict age at first estrus in the gilt.

5) D.L. Kingsbury and N.C. Rawlings (in preparation). Boar stimulation of first estrus in the gilt causes an increase in basal luteinizing hormone concnetrations.

6) D.L. Kingsbury, R.K. Chaplin and J.F. Patience (in preparation). Cathertization procedures in the gilt: advantages and disadvantages.

Project Personnel

1) Dr. N.C. Rawlings, Supervisor
2) D.L. Kingsbury, Ph.D. candidate
3) Dr. W.D. Currie, Post-doctoral Fellow
4) J. Ravindra, Ph.D. candidate
5) A.C.O. Evans, M. Sc. candidate
6) S. Cook, technician
7) I. Irvine, research assistant
8) Dr. R.K. Chaplin, technical input

TABLE 1. LUTEINIZING HORMONE (ng/ml) AT VARIOUS AGES IN PRE-PUBERTAL GILTS, CLASSIFIED BY TIME OF FIRST ESTRUS

Age at First Estrus (days)	Age at Sampling (days)				
	60	81	102	123	144
Early (9)	0.4 ± 0.1	1.8 ± 0.7^{a}	0.7 ± 0.2	0.5 ± 0.2	0.6 ± 0.1
Middle (20)	0.7 ± 0.1	1.0 ± 0.1^{b}	0.7 ± 0.2	0.6 ± 0.1	0.6 ± 0.1
Late (6)	0.5 ± 0.1	1.0 ± 0.3^{b}	1.0 ± 0.4	0.7 ± 0.2	1.0 ± 0.5
Non-cycling (8)	0.7 ± 0.9	0.4 ± 0.1^{c}	0.8 ± 0.3	0.7 ± 0.1	0.6 ± 0.1

Note: Values are means ± S.E.
Note: Figures within columns having different superscripts are significantly different ($P<0.05$).

TABLE 2. FOLLICLE STIMULATING HORMONE (ng/ml) AT VARIOUS AGES IN PRE-PUBERTAL GILTS, CLASSIFIED BY TIME OF FIRST ESTRUS

Age at First Estrus (days)	Age at Sampling (days)				
	60	81	102	123	144
Early (9)	6.7 ± 1.5^{acd}	5.0 ± 0.7^{a}	3.5 ± 0.7^{a}	1.0 ± 0.2	1.1 ± 0.3
Middle (20)	5.4 ± 0.6^{bcd}	4.5 ± 0.5	2.6 ± 0.3	1.3 ± 0.2	1.2 ± 0.3
Late (6)	6.4 ± 0.9^{ac}	5.2 ± 1.0^{a}	3.4 ± 0.9^{a}	2.0 ± 0.7	1.4 ± 0.4
Non-cycling (8)	4.1 ± 0.5^{bd}	3.4 ± 0.5^{b}	1.7 ± 0.2^{b}	1.5 ± 0.3	1.2 ± 0.3

Note: Values are means ± S.E.
Note: Figures within columns having different superscripts are significantly different ($P<0.05$).